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Measurement of aberrations

In a lithographic projection apparatus (e.g., a wafer stepper or step & scan tool) a pattern on a mask (e.g., a reticle) is projected through a projection system onto a substrate (e.g. a wafer). The projection system comprises, for example, refractive, reflective or catadioptric lens elements. In said projection system aberrations can occur such as coma, astigmatism, and third and fifth order distortions, for example.

In the following, a method is described with which said aberrations can be determined. The distribution of incident angles (at which radiation hits a mask) can be varied by tilting the incoming radiation distribution. Such tilted illumination can be accomplished by, for example, selectively blocking at least part of the radiation (e.g. with a filter) or by explicitly changing the direction of the radiation (e.g. using appropriate wedge-shaped optics, like a prism). Using such tilted illumination a selected part of the pupil of the projection system will be used to image the mask pattern onto the substrate. If (aberrated) radiation hits the substrate at a position different from the expected ideal position (as determined by radiation which is not aberrated by the projection system) the respective displacement is generally caused by aberrations. Said displacement is characteristic of a local phase gradient of a radiation wavefront. By illuminating in this manner at various distributions of incident angles, the phase gradients at a pupil plane of the projection system can be reconstructed from the resulting displacements. In this way, it is possible to determine the contribution of all types of aberrations.

A useful application of this technique is in the determination of focus (i.e., focal plane position) by use of a combination of normal illumination and tilted illumination.

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